Rock Chips

Summer 2007

Alberta Geological Survey

# The Age of Diamondiferous Volcanoes in North-Central Alberta

Alberta entered Canada's modern era of diamond exploration in the 1990s, when diamond exploration companies discovered three separate areas of kimberlitic rocks (volcanic-rock type most likely to host diamonds) in northern Alberta. The diamondiferous Buffalo Head Hills kimberlite field in north-central Alberta (Figure 1), has received the most attention because of the large near-surface kimberlite dimensions (up to 45 ha), potential economic grades (up to 55 carats per hundred tonnes) and a high ratio of diamondiferous to barren kimberlite (26 of the 38 occurrences are diamondiferous).

Despite the significance of this diamondiferous kimberlite field, the approximate age of volcanic emplacement was previously known for only 4


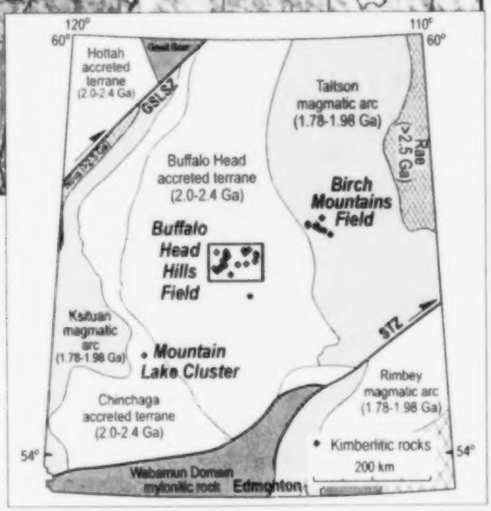


Figure 1. Inset map highlights the inferred basement tectonic domains with the location of ultrabasic to kimberlite occurrences in northern Alberta. The main figure shows volcanic rock occurrences within the Buffalo Head Hills kimberlite field on the bedrock geology base map: bedrock abbreviations Ksh, Ks and Kd reference middle to Upper Cretaceous bedrock units Shaftesbury Formation (shale and silty shale), Smoky Group (shale and silty shale) and Dunvegan Formation (sandstone). Kimberlitic bodies selected for isotopic dating analyses are in larger, bold, italic font.

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of 38 occurrences. This is surprising because geochronological data are critical to understand the timing/distribution of kimberlite magmatism and better constrain their origin, tectonic setting and emplacement mechanisms. Hence, a collaborative project involving the Alberta Geological Survey, Geological Survey of Canada, University of Alberta and Ashton Mining of Canada Inc. presented new age determinations for 12 kimberlitic bodies in the Buffalo Head Hills area using Rb-Sr phlogopite and U-Pb perovskite methods.

Magmatism occurred in at least two separate episodes during the Late Cretaceous (~ 88-81 Ma) and Paleocene (~ 64-60 Ma; Figure 2). Nine kimberlites yield Late Cretaceous ages between 88 ± 5 Ma (U-Pb perovskite, K5A kimberlite) and 81.2 ± 2.3 Ma (Rb-Sr phlogopite, K252 kimberlite). A Danian U-Pb perovskite isochron age of 63.5 ± 0.7 Ma was obtained for the BM2 kimberlite, and Selandian Rb-Sr ages of 59.6 ± 2.8 Ma and 60.3 ± 0.8 Ma were determined for the K1A and K19 bodies, respectively.

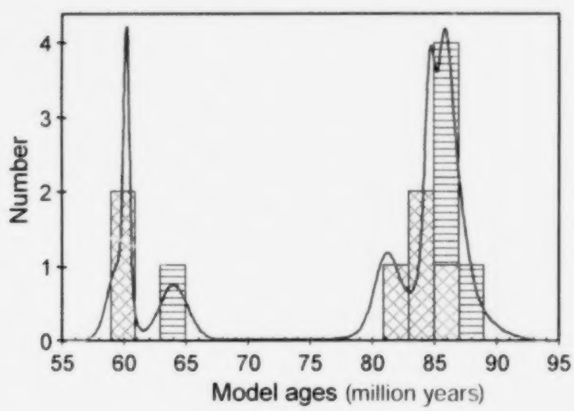


Figure 2. Cumulative probability diagram of phlogopite Rb-Sr isochron ages (cross-hatched) and perovskite U-Pb model ages (horizontal-hatched) that show two distinct episodes of kimberlite magmatism in the Buffalo Head Hills kimberlite field.

We find these two temporal groupings of kimberlite magmatism have distinctly different diamond potential, spatial distribution and emplacement mechanisms. The ~ 88-81 Ma kimberlite group generally occurs in the northwestern part of the field, the kimberlites are diamondiferous, and this volcanism is contemporaneous with sedimentary hostrock deposition, which has important implications for the morphological complexity of the kimberlite bodies. The ~ 64 Ma BM2 body represents the only known occurrence of intrusive (dyke-like) kimberlite in this field and is similar in source composition to the ~ 88-81 Ma kimberlites, but is not diamond bearing. We take this as evidence of mantle


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heterogeneity within the Buffalo Head Hills kimberlite field and thus, make the distinction that diamondiferous bodies could occur outside the northwestern part of the field and vice versa. The ~ 60 Ma ultramafic rocks occur in the southwestern part of the field and are derived from a weakly diamondiferous/barren hybrid (mixed origin or composition) mantle source. The youngest sedimentary rocks in the Buffalo Head Hills belong to the Late Campanian Wapiti Group (~ 78 Ma), so we can conclude that the uppermost portion of the ~ 64-60 Ma bodies (BM2, K1A and K19) are eroded to the current level of erosion.

The contention that diamond-bearing magmatism was prevalent in the Buffalo Head Hills area during the Late Cretaceous (~ 88-81 Ma) satisfies the primary goal of this initiative, which was to provide the information relevant for continued diamond exploration in Alberta. The results have been presented at several geoscience conferences and will be made available in an upcoming Canadian Journal of Earth Sciences special volume highlighting the results of several studies focused on the shallow gas and diamond potential of northern Alberta and northeastern British Columbia. ❖

AGS staff member Roy Eccles logging and sampling kimberlite.

## Upcoming Staff Presentations

Both of these presentations will be given at the 60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference, October 21-24th, 2007 in Ottawa, Ontario.

**Evaluation of Stress and Geomechanical Characteristics of a Potential Site for $CO_2$ Geological Storage in Central Alberta, Canada by Kristine Haug**

Storage of $CO_2$ in deep geological formations has been identified as the most likely near-future option to significantly reduce industrial greenhouse gas emissions in Alberta. To assess the risks associated with potential leakage of the injected $CO_2$ the factors influencing the potential loss of containment need to be evaluated. Currently, there is a lack of publicly available high quality geomechanical data needed for this evaluation. This issue has been addressed in this paper by use of log correlations to establish the geomechanical properties of the geological formations at a potential large-scale $CO_2$ sequestration site.

**Peace River Landslide Project: Hazard and Risk Assessment for Urban Landsliding by Corey Froese**

The location of the town of Peace River, has a large portion of its urban footprint and transportation infrastructure built either on the flood plain or on the unstable valley walls of the Peace River Valley. Beginning in 2006, a study characterized the extent, rates and style of large-scale landslides in and around the municipality. As the glacial history is complex and landslides originate in various settings, the initial components of the study are the development of a three-dimensional geological model and completion of an inventory of documented landslides to determine logical groupings for landslide types. This will be complemented by acquisition and interpretation of airborne LiDAR data in the spring of 2007 and field mapping in the summer of 2007. To develop an understanding of the historical movement rates and extents, an InSAR study will review deformation trends between 1992 and 2006 and compare these results to deformations recorded using conventional instrumentation over this period. Based on the results of these studies, relationships between deformation and external (climatic) factors will be developed to quantify the probability of sudden or accelerated movements in the various landslide groups and data will be incorporated into an overall risk assessment for landsliding in the municipality.

# Buried Channels and Glacial-Drift Aquifers in the Fort McMurray Region, Northeast Alberta (ESR 2007-01)

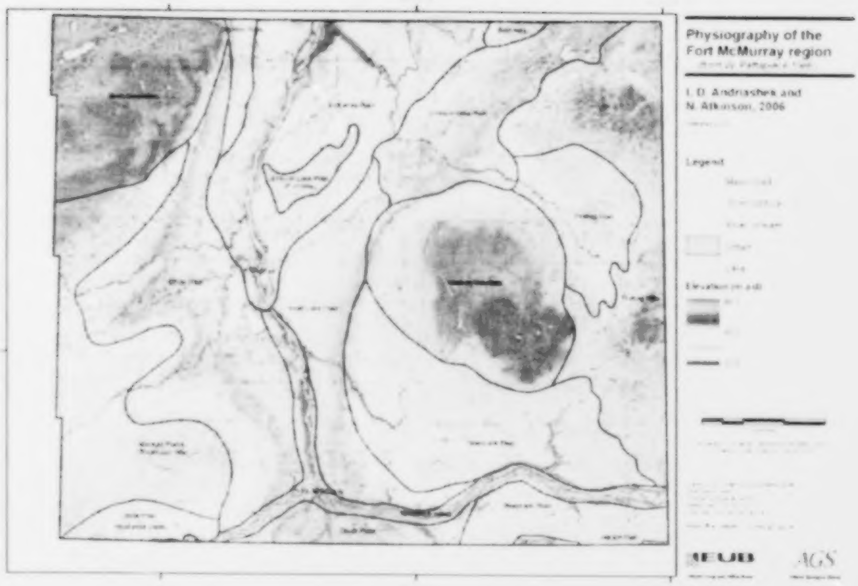
The understanding of the bedrock topography, buried bedrock valleys and channels, drift thickness and glacial aquifers in the surface-mineable and in situ–recoverable oil sands north of Fort McMurray has been updated by the acquisition and interpretation of more than 35 000 borehole logs from the oil sands industry. Interpretations of these new data enabled the construction of a three-dimensional model of the bedrock topography and subcrop, as well as the major buried aquifers contained within buried valleys and channels. From this model, a series of maps and cross-sections has been generated depicting the subsurface distribution of previously known and newly discovered buried aquifers that underlie the oil sands operations in the region.

Numerous buried fluvial erosional features have been mapped on the bedrock surface, either as bedrock valleys formed prior to the last glaciation, or as bedrock channels formed by glacial meltwater. Names have been assigned to the major valleys and channels to facilitate common understanding and discussion between industry, government and research institutions. Many of the buried channels exhibit features indicative of erosion by subglacial meltwater under a significant hydraulic head. These channels, referred to as tunnel channels, are commonly narrow, deeply entrenched, discontinuous to anastomosing and unconstrained by the topography of the preglacial landscape. Subsequent deposition of glacial sediment has effectively masked any surface expression of the buried valleys and channels on the modern landscape. As a consequence, and given their narrow form and discontinuous nature, many channels fall between regional oil sand resource-evaluation boreholes and remain undetected following initial exploration drilling. Mapping of the bedrock topography and buried drift aquifers also has been complicated by glaciotectonism, which has disrupted the normal stratigraphic setting in some areas by the processes of glacial thrusting, displacement and superposition of pre-existing strata on younger units.

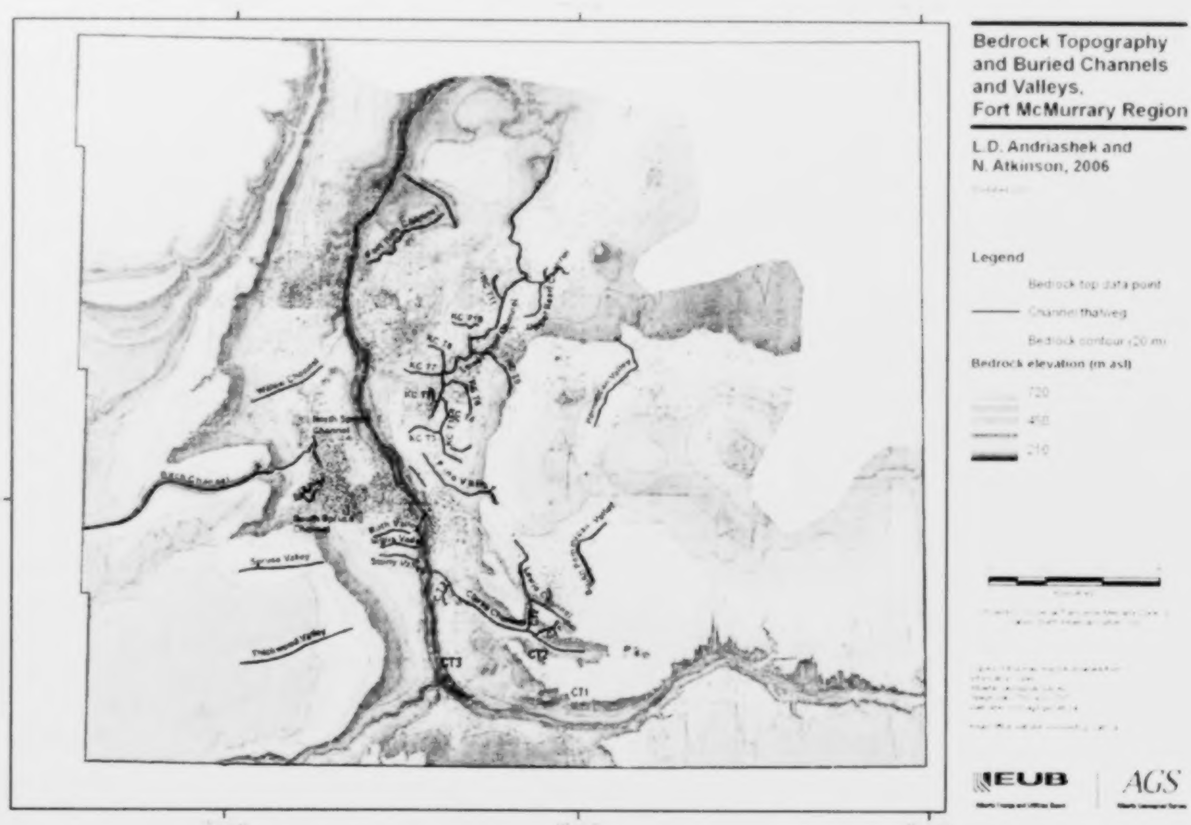
Most of the buried bedrock valleys and channels contain a thick infill, as much as 90 m thick, of water-saturated, coarse fluvial sediment ranging from fine sand to metre-sized boulders. These constitute buried aquifers that may be targets for the supply of potable water for municipal and industrial use. In places, the tops of the aquifers lie within 5 m of the surface. Unlike continuous and extensive aquifers found in large, preglacial bedrock


Location of the Athabasca Oil Sands area

valleys south of the study area, buried glacial aquifers in the Fort McMurray area are confined to isolated channels and valleys. Although they do not form a continuous, well-connected network throughout the oil sands region, buried valleys and channels can function as natural pathways for the subsurface movement of water or other fluids at the local scale.




The geological interpretations presented in Earth Sciences Report 2007-01, are intended to provide the basis for a hydrogeological characterization of the groundwater contained within buried glacial aquifers in the Fort McMurray region. Recommendations are provided for further characterization of the hydrogeological setting of the drift and upper bedrock units in the region. ❖



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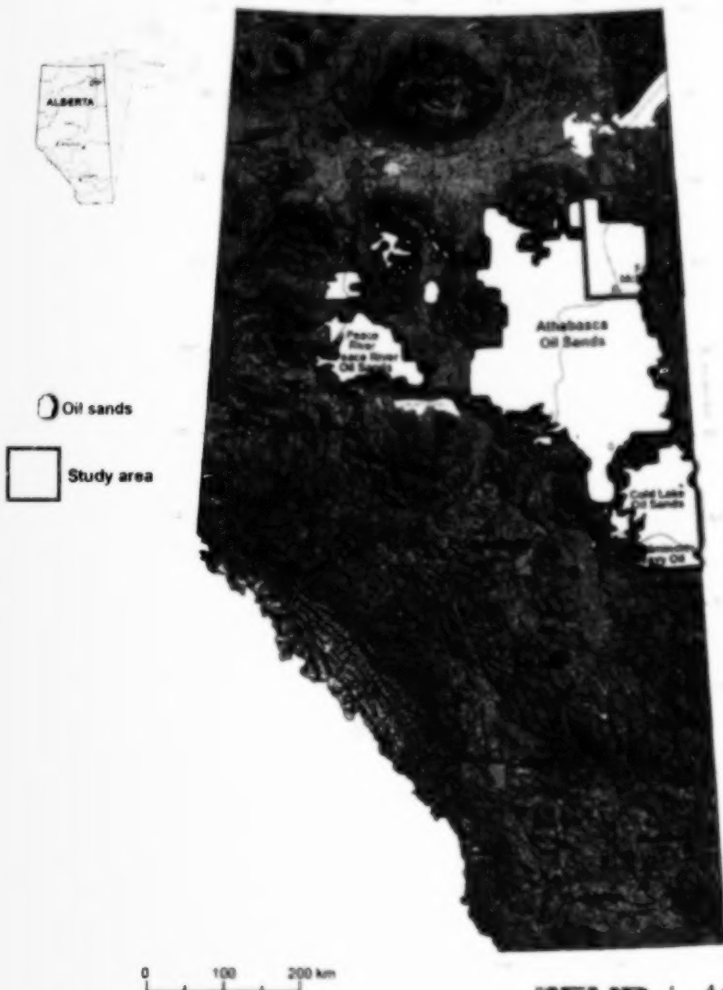


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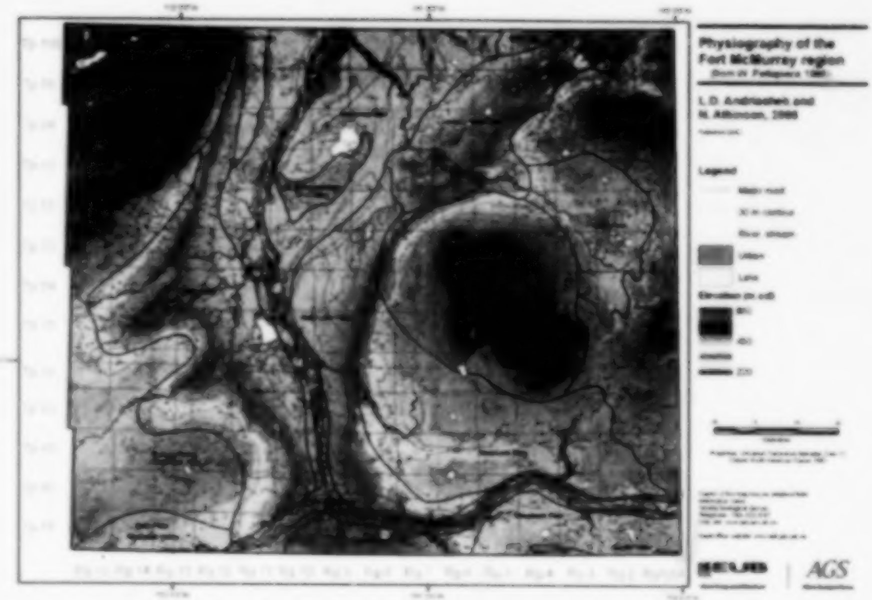


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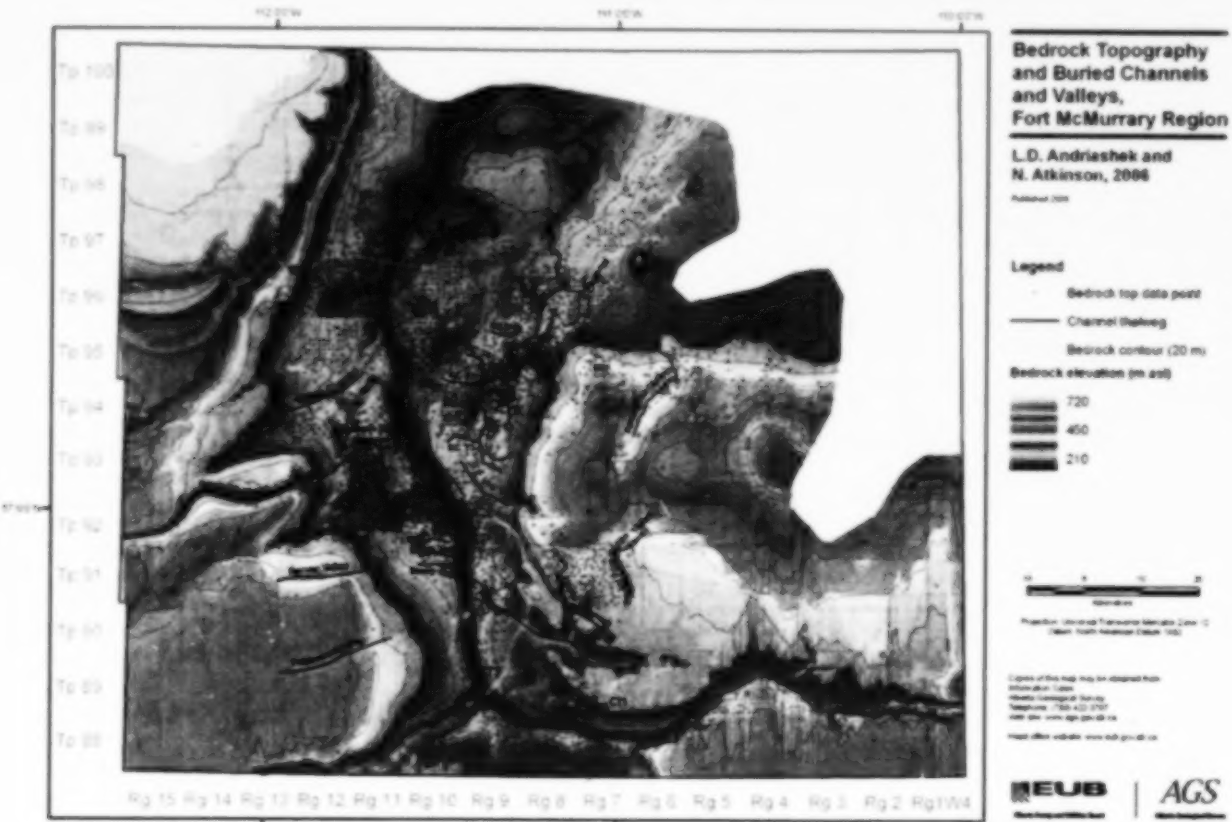

# Recently Released Publications

## Digital Datasets

**DIG 2007-0006** Alberta Diamond Inclusion Dataset. ZIP (0.03 MB)

**DIG 2007-0008** Alberta Kimberlite Xenocryst Dataset. ZIP (0.29 MB)

**DIG 2007-0009** Alberta Diamond Occurrences Dataset. ZIP (0.04 MB)

## Earth Sciences Reports

**ESR 2007-01** Buried Channels and Glacial-Drift Aquifers in the Fort McMurray Region, Northeast Alberta. 335 MB PDF. $20.00.

**ESR 2007-04** Ardley Coal Zone Characterization and Coal-Sandstone Channels Architecture, Pembina CBM Exploration Block, Alberta. 277 MB PDF. $20.00.

**ESR 2007-05** Regional Correlations of the Ardley Coal Zone, Alberta. 121 MB PDF. $20.00.

## Maps

**MAP 278** Sand and Gravel Deposits with Aggregate Potential Grande Prairie, Alberta (NTS 83M). Scale 1:250 000. 4.37 MB PDF. $20.00.

**MAP 286** Sand and Gravel Deposits with Aggregate Potential Winefred Lake, Alberta (NTS 73M). Scale 1:250 000. 1.29 MB PDF. $20.00.

**MAP 299** Sand and Gravel Deposits with Aggregate Potential Iosegun Lake, Alberta (NTS 83K). Scale 1:250 000. 1.46 MB PDF. $20.00.

**MAP 317** Sand and Gravel Deposits with Aggregate Potential Clear Hills, Alberta (NTS 84D). Scale 1:250 000. 2.11 MB PDF. $20.00.

**MAP 319** Sand and Gravel Deposits with Aggregate Potential Lake Claire, Alberta (NTS 84I). Scale 1:250 000. 2.89 MB PDF. $20.00.

**MAP 322** Sand and Gravel Deposits with Aggregate Potential Mount Robson, Alberta (NTS 83E). Scale 1:250 000. 1.5 MB PDF. $20.00.

**MAP 323** Sand and Gravel Deposits with Aggregate Potential Brazeau Lake, Alberta (NTS 83C). Scale 1:250 000. 4.09 MB PDF. $20.00.

**MAP 416** Bedrock Topography of Bistcho Lake Area (NTS 84M), Alberta. Scale 1:250 000.

**MAP 417** Drift Thickness of Bistcho Lake Area (NTS 84M), Alberta. Scale 1:250 000.

Maps 416 and 417 are sold together on 1 CD for $25.00.

## Special Reports

**SPE 087** Chemistry of Kimberlite Indicator Minerals and Sphalerite Derived from Glacial Sediments of Northwest Alberta. 3.79 MB PDF $20.00.
(also released as Geological Survey of Canada Open File 5545)

### Story Contact Information

The following AGS staff members may be contacted for further information on their articles or citations.

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| Buried Channels and Glacial-Drift Aquifers in the Fort McMurray Region | Laurence Andriashek | (780) 427-1759 |

Staff may also be contacted via e-mail by entering the author's first name.last name@eub.ca

Comments and suggestions for Rock Chips may be sent to Maryanne Protz at maryanne.protz@eub.ca

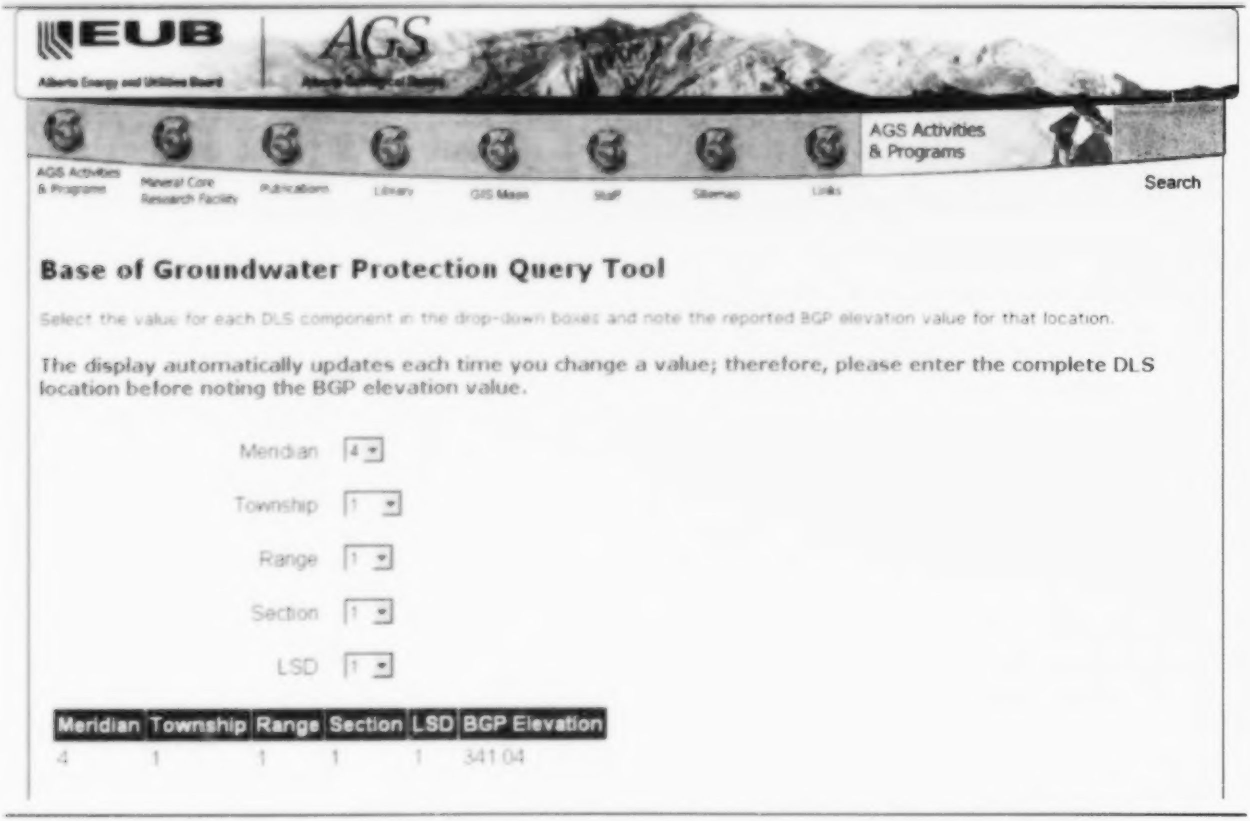
# Base of Groundwater Protection Now Available Through a Web Tool

In 2005, Alberta Environment commissioned the Alberta Geological Survey (AGS) to map the base of groundwater protection (BGP) across Alberta. AGS updated and completed Statistical Series 55-2007, Alberta's Base of Groundwater Protection (BGWP) Information, using a geostatistical mapping process with stratigraphic information as the basis for the interpretation. The BGP is the best estimate of the depth at which saline groundwater is likely to occur. As of April 2, 2007, the Base of Groundwater Protection response service is provided by the EUB Environment Group. BGP information is now available at the legal subdivision (LSD) level through a web tool at www.ags.gov.ab.ca/activities/Groundwater/base_groundwater_protection.html.

Information is available for most Dominion Land Survey locations in Alberta, at the legal subdivision level, except the mountainous region (disturbed belt) and the very northeast corner of Alberta. Within the mountainous region, the BGP interpretation is unchanged at 600 metres below ground level. The depths below ground or below the kelly bushing (KB) at locations outside this area can be calculated by subtracting the elevation provided by the web tool from the ground or KB elevations, respectively. In the case where the depth is greater than or equal to 600 metres below ground level, the BGP is set at 600 metres below ground level by default.

The EUB recognizes that local variations may exist that are not captured by a regional assessment. Therefore, if a company believes the BGP depth for a specific location is not accurate, it may choose to submit data that would support a change to the BGP for that location. The EUB would accept representative water analyses from the subject well or wells in adjacent sections in support of such a request. Drillstem test data, short-term flow test results or log-based salinity calculations will not be accepted.

Questions regarding the base of groundwater protection must be directed to the EUB Environment Group at (403) 297-8330 or enviro.services@eub.ca. ❖



# Conferences and Presentations Involving Alberta Geological Survey

**60th Canadian Geotechnical Conference and 8th Joint CGS/IAH-CNC Groundwater Conference**
October 21-24th, 2007
Ottawa, Ontario

**9th Annual Unconventional Gas Conference**
November 14-16, 2007
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Calgary, Alberta

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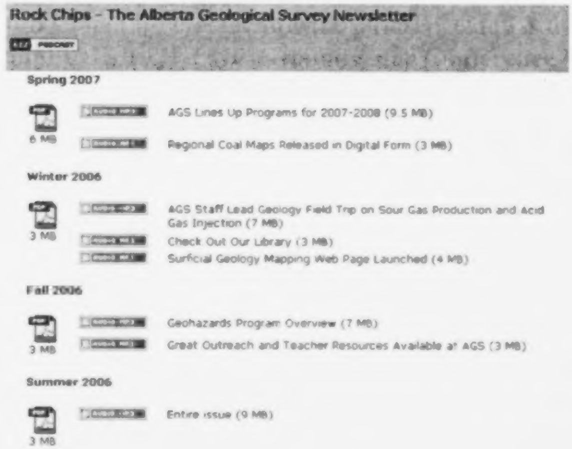


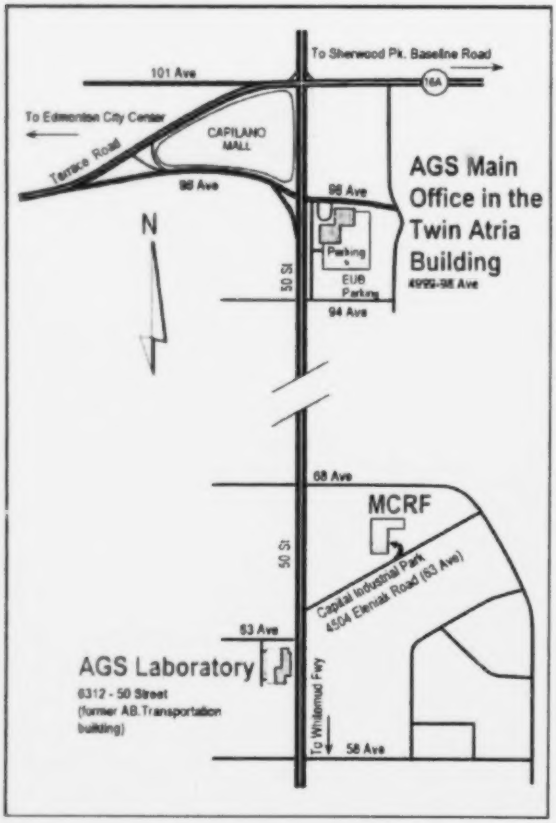


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Our Mineral Core Research Facility (MCRF) is located at
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For information on the MCRF or to book a visit, contact Rob Natyshen by phone at (780) 466-1779 or by e-mail at Rob.Natyshen@eub.ca